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ArchiCAD template for architectural offices

Enhancing workflow at JLL Finland

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Civil Engineering

Sustainable Building Engineering

28 April 2017

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Number of Pages Date	40 pages + 1 appendix 28 April 2017
Degree	Bachelor of Engineering
Degree Programme	Civil Engineering
Specialisation option	Sustainable Building Engineering
Instructor	Eric Pollock, Senior Lecturer
<p>The goal of this thesis was to create an improved starting template for ArchiCAD 20. The template was to enhance the productivity of an architectural office and make modelling compatible with COBIM 2012 requirements.</p> <p>The project was carried out in three phases. First, information on best modelling practices was gathered from online sources and COBIM 2012 guidelines. Second, designers and engineers were interviewed to create the template according to their needs. The final phase was modifying the modelling tools within ArchiCAD to finish the template.</p> <p>The final result was a new starting template that underwent a testing period. During the testing period a few errors were found and fixed, a critical program failure was reported to Graphisoft and a wide variety of recommendations for further modifications were made.</p> <p>The ArchiCAD template turned out to be successful, promising to be useful in day-to-day work of an architectural office. Future modifications and upgrades seem plausible and the template will undergo further modifications.</p>	
Keywords	ArchiCAD, template, architectural office

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1 Introduction

The goal of this thesis is to create a template for ArchiCAD 20 that would be more intuitive to use than the earlier versions, and one that would enhance the productivity of architectural offices. It is also vital that the user interface directs designers towards modelling with greater emphasis on making the architectural models truly intelligent, following the modelling guidelines set by Common BIM Requirements 2012 (COBIM 2012).

At the moment, modelling is not done to its full potential, making it almost impossible to consider the output of ArchiCAD as a Building Information Model (BIM). Due to the complexity of the program, designers tend to use parametric modelling tools, that are three dimensional (3D), and two dimensional (2D) drafting tools together. The result is a mixed model that is half 3D and half 2D, making further simulations and quantity take offs impractical if not impossible. Improper 3D models also add to the workload of 3D visualization teams, causing further costs to clients or cutting profit margins for the company providing architectural services. However, most complexity issues can be addressed by proper planning by the BIM manager and by setting company standards for the use of ArchiCAD tools.

The scope of this thesis is to give specific parameters to the modelling tools in ArchiCAD toolbox. The modelling tools are modified, parameters added and minor tweaks made to a number of other settings within ArchiCAD. The non-modelling tools modified are the layout views, pen sets, the 2D line tool and the tool for creating sections. This thesis is based on experience and research into ArchiCAD that was made for JLL Finland.

2 Theory for computer modelling

The thesis aims at resolving issues of modelling practices in ArchiCAD and some background knowledge is needed. The theoretical background looks into three key items affecting the making of a good ArchiCAD starting template. These are the rules and guidelines set by Building Smarts COBIM 2012, the use of RT building information cards and the use of modelling software, ArchiCAD. Chapter 2 provides an overview of the history and use of the key items. For clarification purposes, the chapter begins with a description of BIM.

2.1 Building Information Modelling

Building Information Modelling is a process that results in a digital representation of a physical place and its function. The aim is to digitally construct the project at hand to find out problems that might emerge, like clashes and structural faults, before committing to the project in reality. The final output is a model that contains as much information as possible to be used in decision making, simulations and the creation of construction plans. Currently, BIM models are mostly used in the construction industry, but they are also generating interest in the service industry. [1.]

2.2 ArchiCAD

ArchiCAD is a computer software used in the construction industry by designers, engineers and contractors. It is considered as one of the leading BIM programmes on the market with a long history going back 30 years [2].

ArchiCAD is owned by a Hungarian company called Graphisoft. The development of ArchiCAD started in 1982 and the first working version was released in 1984. [3.] ArchiCAD is recognized as the first computer aided drafting (CAD) program for personal computers that was able to create 2D drawings and 3D geometry [4]. In 1987 the company launched ArchiCAD 3.0 which incorporated the company's new concept of "Virtual Building". Virtual Building added colour information to the regular 2D and 3D drawings, setting the trend for CAD programs to move towards BIM. [3.]

The latest version on the market is ArchiCAD, used in this project. One of the key changes from ArchiCAD 19 to 20 was the way Favourite Settings are displayed. The new user interface is designed to streamline the workflow by making it more intuitive to use. [5.]

ArchiCAD was chosen for this project because the customer, JLL Finland, uses ArchiCAD in their architectural department. Furthermore, this final year project is not the first step in customising ArchiCAD at JLL Finland. Prior work has been put into making a custom template for the company. The JLL template is further customized in this thesis.

Use of ArchiCAD

Designing and modelling in ArchiCAD should be done with correct modelling tools. There are tools for different building elements, like walls and stairs. For further detail work, 2D drafting tools, like lines and markers, can be used. For the scope of this thesis only the tools and settings affecting the creation of the new ArchiCAD template are looked into. They are the toolbox menu, which holds various modelling tools, and the favourite settings tab. For instructions on how to use ArchiCAD in general, the first part of Rai Sandips 2016 thesis “Design of single family house using BIM software” is recommended [6].

Toolbox

The toolbox is a menu bar that gives access to the most frequently used tools in the program. Due to the complexity of design work, the number of tools has to be rather high, making quick-mapping tools to keyboard shortcuts far too complicated. This is resolved by having a handy toolbox with almost everything needed for modelling. Figure 1 below shows what the toolbox looks like in two different configurations. Because the majority of JLL Finland architects use the Finnish version of ArchiCAD, all following screen shots taken from ArchiCAD have Finnish texts.

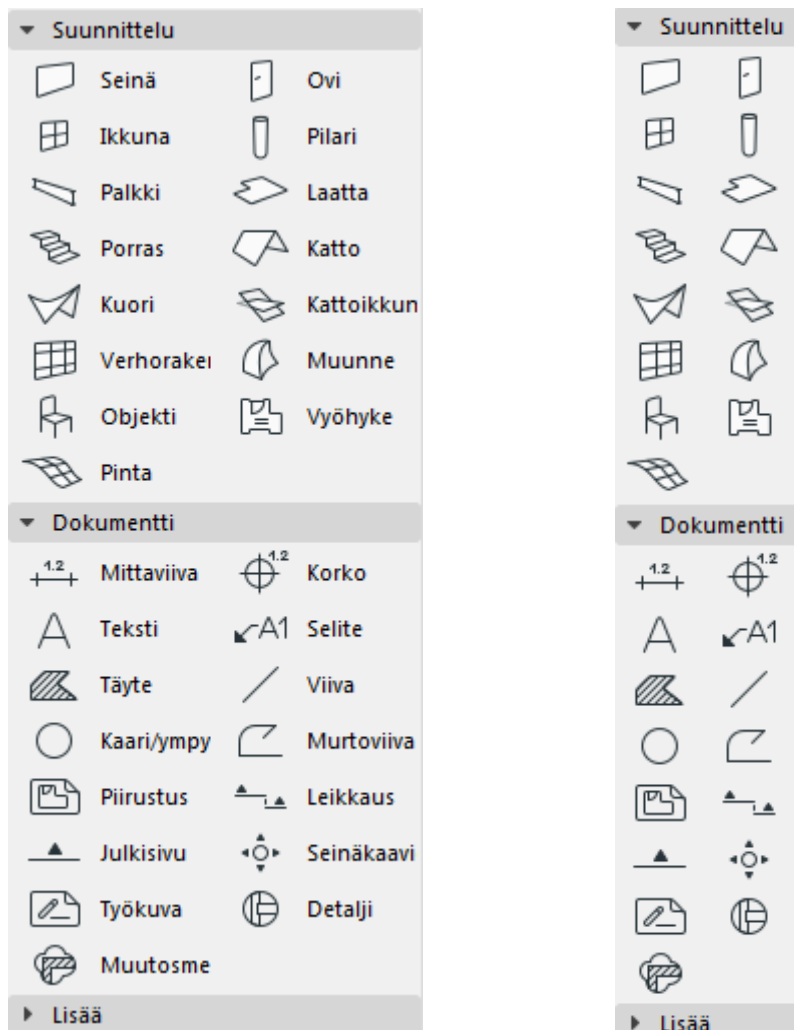


Figure 1. ArchiCAD toolbox views.

On the left, the toolbox is set to display not only the drawings but also the names of the buttons. This is good for people new to ArchiCAD or new to the latest version. On the right, the same toolbox is displayed in a minimized version, without names, to have more room in the workspace area. In both display styles, the buttons are made out of line drawings for scaling purposes [7].

Favourite Settings

In architecture there are standard materials and elements that are commonly used in the construction field. The standard materials and elements can vary from country to country and even from company to company. To achieve a higher efficiency during drafting phase, ArchiCAD has a Favourite Settings capability. The Favourite Settings store required information about the materials and elements for later use, removing the need to

specify all of the needed parameters again. In figure 2 below, a specific window has been selected from a stored list of favourite windows. The window now has information about the dimensions, materials used and other vital characteristics.

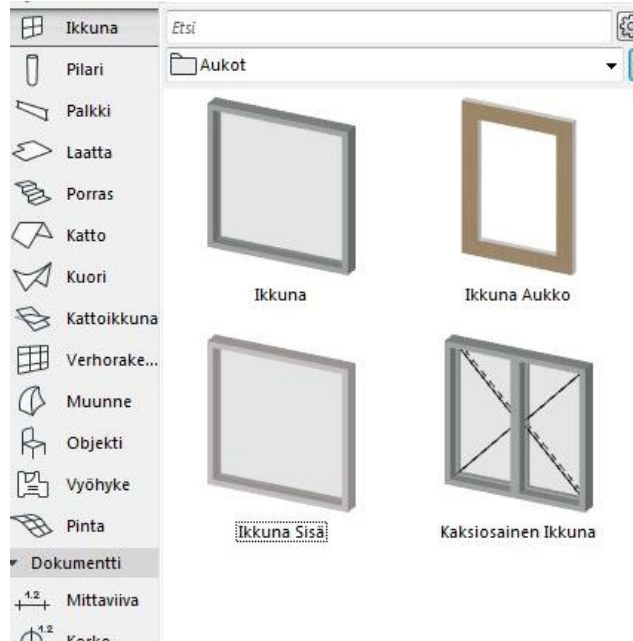


Figure 2. Favourite Settings quick window. Displaying windows.

The quick box for Favourite Settings is a new feature added in ArchiCAD 20 and it is to be the backbone of the template for JLL Finland.

2.3 Rakennustieto

Rakennustieto (RT) is a Finnish company with a mission to establish good building practices. RT has a vast library on building materials, elements and instructions for construction used in Finland. It has collected information on a variety of topics related to construction since 1942. The first instructions were officially released to help Finland rebuild after the damages caused by the Second World War. The instructions are referred to as information cards. [8.]

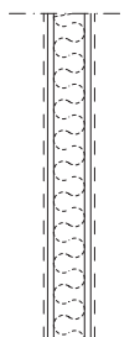
For this paper, RT was a source of information on commonly used construction materials and objects, such as doors and windows. RT has information cards for almost all of the commonly used wall, floor, foundation and roof structures.

Use of Rakennustieto building information cards

The construction industry is highly regulated and it is impractical to try to memorize the vast amount of information architects and engineers need. To store and access information on regulations and building elements, RT has building information cards with charts and guides. RT building information cards are used daily to look up information as needed.

RT 82-10903		ohjetiedosto		22
Rakennuskohde		Teräsrankseinä RT VS 601		
Suunnittelija		VS		

Mittakaava 1:10



Rakennekerrokset:

≥ 8 mm	Seinäpinta ja pintakäsittely huoneselosteen mukaan
≥ 66 mm	Rakennuslevy rakennuslaskuksen mukaan
	Kantava rakenne, teräsranka k 600
	Ääneneriste, tarvittaessa
≥ 8 mm	Rakennuslevy rakennuslaskuksen mukaan
	Seinäpinta ja pintakäsittely huoneselosteen mukaan

Figure 3. Part of RT card on partition walls. [9.]

Figure 3 shows a specifics sheet displaying a partition wall with information about the different building material layers listed. The code for this specific wall, RT VS 601, is based on Talo2000 nomenclature [9].

2.4 BuildingSMART

BuildingSMART is an international organization with a goal to improve the way various computer programs in the construction industry interact. Industry Foundation Classes (IFC) was developed by BuildingSMART to have a neutral and open source computer

language that would be understood by most programmes used in the construction industry. The IFC computer language is constantly improved by BuildingSMART and the users of various programs around the world. [10.]

BuildingSMART started in 1994 when Autodesk invited a group of 12 US based companies to develop a set of C++ classifications to support integrated application development. The following year the first functioning classification system was published and the company, known as the International Alliance for Interoperability (IAI), opened its membership for all interested parties. In 1997 they registered as a non-profit organization focused on creating a neutral language, the IFC. The company name was changed to BuildingSMART in 2008. [11.]

BuildingSMART has several branches around the world and the Finnish branch is of interest to this thesis [12]. The Finnish BuildingSMART has released a set of instructions in 2012 called COBIM 2012 which serve as guidelines for the ArchiCAD template being created and set good modelling practices to follow.

Use of BuildingSMART COBIM 2012 guidelines and requirements

The COBIM 2012 requirements introduce a number of crucial factors to modelling in a proper way to make BIM models more efficient. For the purpose of this thesis and the template that is made, COBIM 2012 series 1 to 3 and series 7 are taken into consideration. Series 1 deals with general modelling rules, setting guidelines to how BIM software should be used. In the series 2, COBIM 2012 takes a more in depth look at the starting situation of a model. Series 3 is specialized in architectural models and the requirements specific to an architect's work. In series 7, quantity take-offs are discussed and specifications made. [13.]

The most important thing to remember from series 1 is the proper use of layers. The layering may differ from that of traditional CAD drafting software, and currently there is no industry standard methodology to naming the layers. Therefore it is important to document the layering methodology used in a BIM specifications file and in the tender documents [14]. This thesis and the template created use the Talo2000 layer system.

From the second series of COBIM 2012, the JLL Finland template incorporates the BIM specifications file. A BIM specifications file is a written document that keeps track of how

and why decisions for modelling are made. The file type is not specified and in the case of the new JLL template a written document is created. The document can be exported either as a PDF or as an Excel file for further editing. The BIM specifications file is used to document the use of layers, IFC format, origin of source data, deviations in the use of modelling tools, software version, measuring methods and the coordinate system used. [15.]

Modelling tool usage and floor elevation specifications for the JLL Finland template are taken from COBIM 2012 series 3. According to good practices set by series 3, all modelling tools strictly follow building floor heights. Elevations of floors are set to start from the finished floor and accordingly, wall coordinates start at the same height. Each building element is modelled with the proper tool and any deviations from this are documented in the BIM specifications file. Due to the requirement of proper tool use, glass walls have to be modelled with the wall tool. [16.]

Series 7 was taken into consideration in determining the level of detail for the template. The level of detail has to be consistent through the whole BIM model to ensure good quantity take-offs [17]. A high level of detail was chosen because ArchiCAD has model view settings than can simplify the model as needed. This way future quantity take-offs can be made in an efficient manner, yet the 2D plans can be simplified when needed.

3 Creation of a template

To increase the efficiency of ArchiCAD use, custom templates are a common solution. Templates give quick access to the main objects and design tools with pre-set specifications used in the modelling process, removing the need to remodel common elements in every project. The aim of this final year project is to make the design process and modelling faster while applying the good practices set by COBIM 2012 rules.

The process of making the ArchiCAD template was made in three separate phases. The first phase was information gathering. Information was gathered from two kinds of sources, which is written material, consisting of COBIM 2012 books and online sources on the subject. The majority of the online material came from ArchiCAD's website. ArchiCAD's website has an extensive tutorial section and a forum area with a community of ArchiCAD users who have dealt with topics missing from the tutorial section. Another

online source for tips on using ArchiCAD came from shoegnome.com. Shoegnome is an architectural company that hosts a blog discussing topics relevant to modern architects and ArchiCAD users. Besides the written material, previous projects made with ArchiCAD were analysed by using quantity take-offs, exporting models into IFC and by looking for common modelling mistakes. All of the mistakes were related to improper use of modelling tools and objects in ArchiCAD.

The second phase of the template creation was interviewing designers. All participants were handed a short questionnaire based on a model analysis. The questionnaire asked about the core modelling tools used, and inquired what the designers wanted the tools to be like. When the questionnaire was completed, a personal interview was conducted. Besides employees of JLL Finland, a few engineers from the companies NCC and YIT construction filled in the questionnaire and took part in the interview. On the 11th of April 2017, a short interview was conducted with a Graphisoft representative, Ville Pietilä, during an ArchiCAD training session at JLL Finland.

The third phase in the creation of the template was the process of actually creating the new ArchiCAD template. As a start, favourite settings for most of the working tools in the toolbox design compartment are modified. For the scope of this project not all of the tools received an equally thorough modification. In the thesis, the tools are covered in the same order as they are listed in the toolbox. Figure 4 lists the tools and shows which are left out from the process.

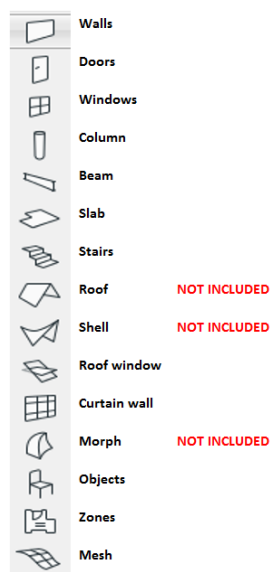


Figure 4. The list of tools in ArchiCAD.

As seen in figure 4 above, the roof, shell and morph tools are left out of the template. The roof tool was left out because architects usually do not design the roof structure and the type of the roof depends on the project. Morph and shell tools are used in a very peculiar ways. According to the interviews and analyses done on prior models, the shell tool had little to no use for designers. The usage of morph tool should be avoided for structural purposes. Morph tool is most used for custom furniture and they are outside the scope of this thesis will not look into that.

3.1 Wall tool

The wall tool is the most widely used tool and also one of the simplest to modify. The problem with the default settings is that the height of the walls is incorrect. Furthermore, the default layer is incorrect. ArchiCAD has also a set of pre made composite walls that do not seem to have much use in the Finnish construction field. For the JLL template a new set of favourite walls is created. Besides favourite walls, new composite walls are assigned according to the RT cards and complex glass wall types are created. The favourite walls are listed below with the name in Finnish and given in italics.

Foundation wall, *Perustus*

The wall type foundation wall is used in almost all projects. To ensure proper modelling of a foundation wall, it is important to select the right layer and proper IFC settings. According to Talo2000 layer system, the layer has to be “AR121 Perustus” and the wall has to be a load bearing structure. The material for the wall is reinforced concrete, but any building material could work, as long as it has the structural strength, which defines the material strength in ArchiCAD, set to be in the high 700 range. To visually tell the foundation wall apart from the other wall types in the favourite’s window, a complex wall profile was selected for the foundation, giving it a familiar foundation shape. The foundation wall used in the template can be seen in figure 6.

Partition walls, *Kantava Sisäseinä* and *Väilseinä Yleinen*

Partition walls come in two different styles, load bearing and non-load bearing. The Finnish construction regulations require apartments to be separated with a fire resistant wall [18]. The fire resistant wall is often a load bearing concrete wall because concrete walls meet fire safety regulations. Buildings also need structural load bearing walls to carry the dead load of a building. This is why combining a fire resistant wall and a load bearing

wall into one is a common practice in the Finnish construction field. Figure 5 below shows the setting tabs for the two types of partition walls.

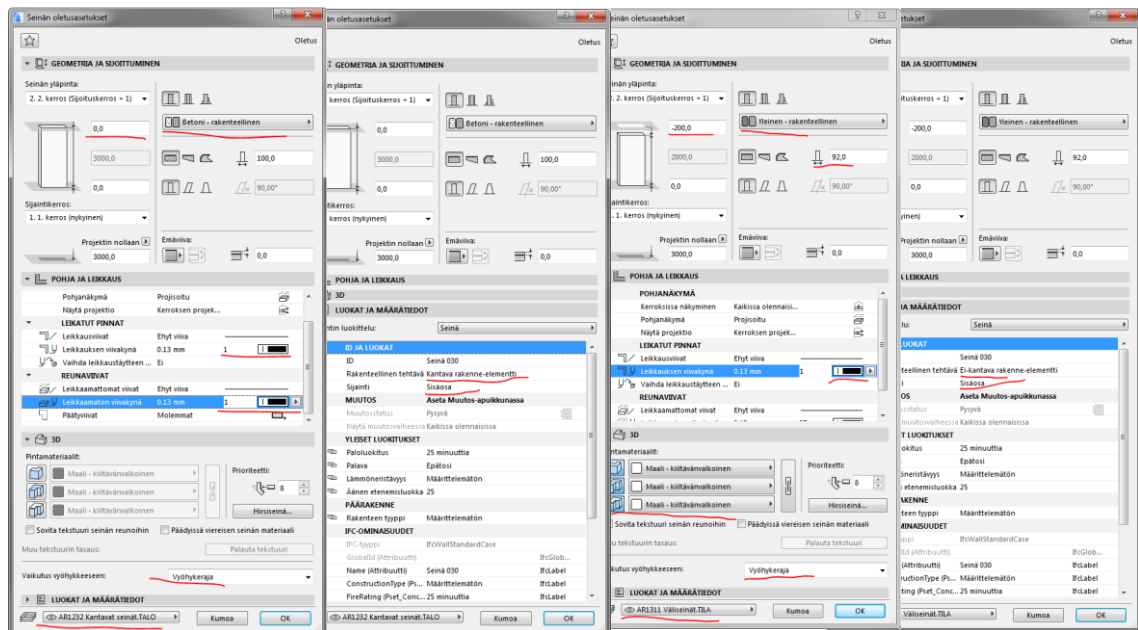


Figure 5. Interior walls. Structural bearing and non-bearing.

The first two parts in figure 5 show the settings for the load bearing partition wall. The important things to pay attention to are the height, the building material used and the layer. For a load bearing partition wall, the IFC settings tab specifies that the wall is “load bearing” and situated “inside” the building. The right part of figure 5 shows the settings tab for a non-load bearing partition wall. The wall material is set to *General Material* and, for ease of use, the wall has been set to the common width of 92mm. 92mm is the most commonly used width of partition walls in Finland. Surface material, which defines the visual presentation in a 3D model view, is set to white colour. According to IFC settings, the wall is “non-load bearing”. Both wall types use a black pen for 2D drawings. *Pen 1* in ArchiCAD sets the line colour to black. Black colour for 2D lines is used to achieve a simple and a clean drawing.

Load bearing outside wall, *Kantava Ulkoseinä*

No building can be modelled without an outer wall. Outer walls vary from project to project so the composition of the outside wall in the JLL template cannot be pre-set. For the JLL template, a generic composite wall is used to make the wall stand out visually in the favourites window. Figure 6 below shows the wall in the favourites window.

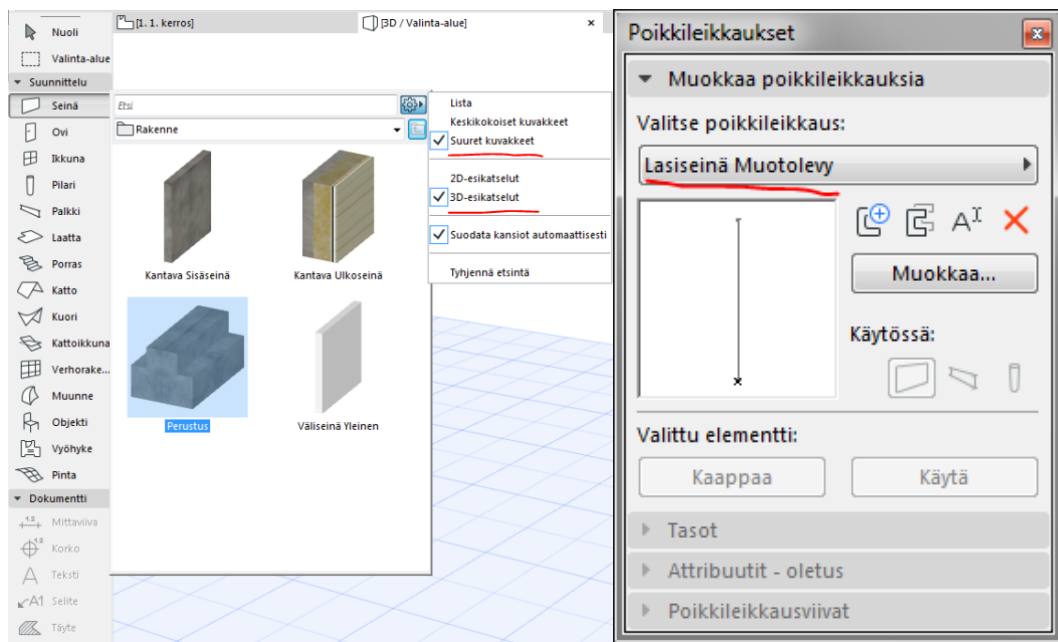


Figure 6. Favourite walls and glass wall.

On the left hand side, in figure 6, the outer wall is shown with the composite material displaying different building materials used. The important thing in setting up this wall type is to assign it the IFC specifications, the correct height and define pens for a 2D presentation. In the IFC settings the wall is “load bearing” and located “outside”. The height is 3000mm and all pens are set to pen number 1. For load bearing outer walls the layer is “AR1241 Ulkoseinät” according to Talo2000 system.

Composite walls and complex profile for glass wall

Interviews with architects made it apparent that the composite wall profiles that come pre-made with ArchiCAD were not often used. For most projects four new types of composites that suit the Finnish construction landscape were almost all ways created. Figure 7 shows the four wall types. All of them are partition walls and used with the wall type “Väliseinä Yleinen”. Composite walls are created and named according to the RT card regulations.

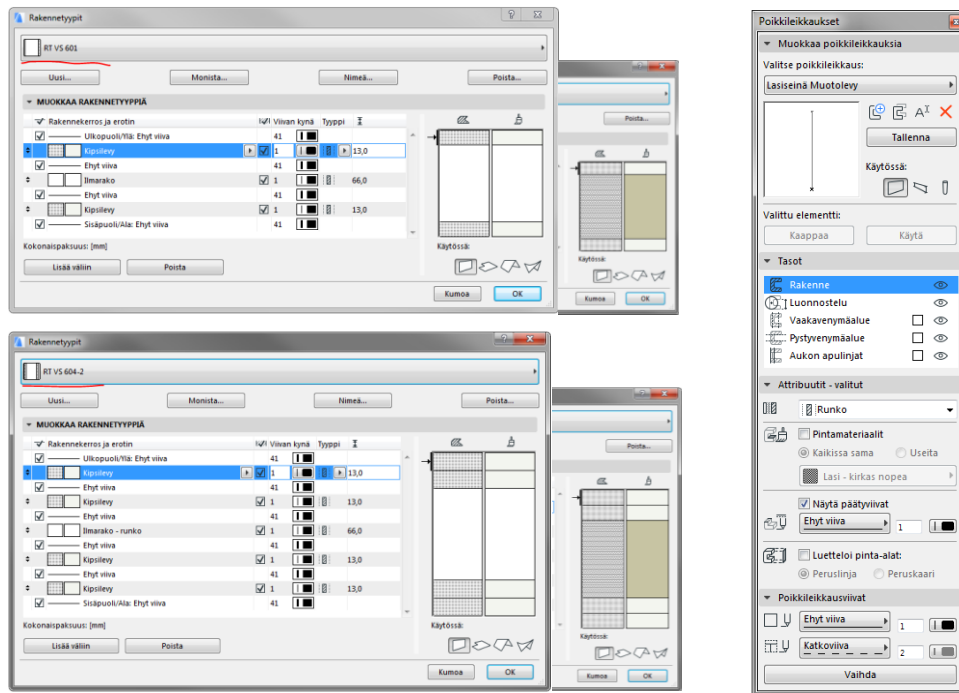


Figure 7. The four composite walls and the glass wall.

Besides the composite walls, the interior designers at JLL Finland wanted to have a glass wall tool. To comply with the COBIM 2012 regulations, the glass wall has to be modelled with the wall tool. That is why a glass wall complex profile is created. Figure 7 shows a cross section of a 2200mm high glass wall and its side view can be seen. The glass wall is modelled Muotolevy products, in three different height versions. Muotolevy product information can be seen in appendix 1.

3.2 Door tool

JLL Finland has decided to use the Finnish “Peruskirjasto” door objects for all future modelling purposes. “Peruskirjasto” is the ArchiCAD objects library that is developed for the Finnish market by Graphisoft representatives in Finland. The default door list in ArchiCAD’s original objects library has caused problems for some of the architects at JLL Finland due to the complexity of the settings tab. To resolve this, a uniform modelling approach was decided on, and for the JLL template, five different door types are made.

Exterior door and Balcony door, *Ulko-ovi* and *Parveke ovi*

Exterior doors, both the balcony door and the regular exterior door, differ from other doors by their frame width and the IFC specification for location. The door width has to be at least 170 mm. However, a 210mm width is becoming more common on the market, and it is the one used for the JLL template [19]. Under the IFC specifications both doors are listed as “non-load bearing” and the location is set to be “outside”. The doors are also given an ID name in the IFC specifications. In the future, the ID name is used when generating door lists. Figure 8 shows some of the settings tabs that have to be modified are shown.

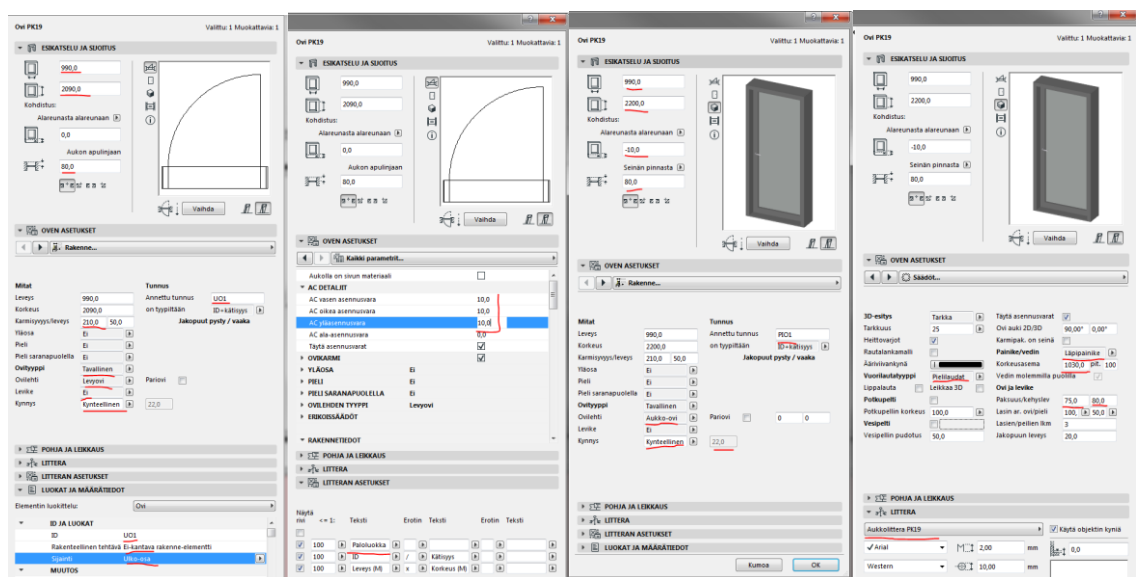


Figure 8. Exterior door and balcony door.

Both exterior doors in the template are 990mm wide and an extra 10mm is added to the wall hole on all sides for fitting needs. The balcony door is higher than a regular exterior door. This is a common practice to make balcony doors line up with the windows used on balconies. Both doors have an information letter type “Aukkolittera PK19”. The information letter displays the width and height of the door in rounded decimetres and shows the door ID name. The information letter is visible on 2D plans only on a scale of 1:50 or if a specific model override has been activated.

Interior doors in various sizes, *Sisäovi 8-10x21*

Interior doors are the door type used most often during the design phase of a project because most buildings have more interior than exterior doors. Until final construction plans are made or suppliers of doors selected, general interior doors are used. The width and height of these doors follow the Finnish standards.

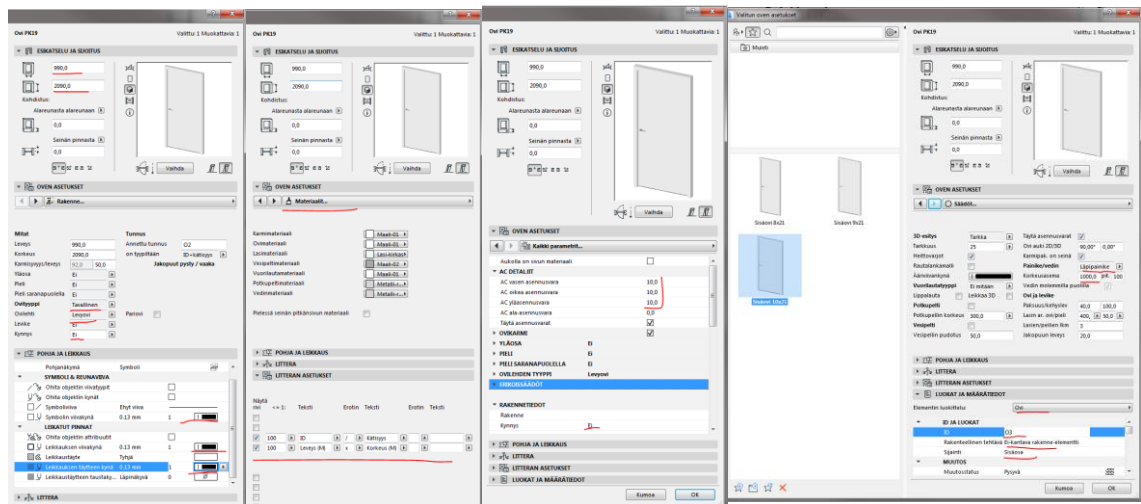


Figure 9. Doors used inside a building.

Figure 9 shows which settings tabs are modified, as well the three width versions of the doors that are created. All doors are 2090mm high and the width varies from 790 to 990mm. For mounting needs, the opening hole for all doors is 10mm bigger on all sides except the bottom. The bottom elevation is not changed so that the final elevation of the door is as exact as possible. All doors have a generic white look, since white is the most commonly used door colour in Finland. For 2D representation, all 2D drafting lines are set to pen colour 1 for a clean and simple result. The doors do not have a threshold. If a door is used as a toilet door, a threshold needs to be added. To quickly change threshold settings, all doors are saved so that further editing opens the settings tab in the area where a threshold can be modified. IFC specifications set all the doors as “inside”, “non-load bearing” and the ID of the doors is “O1”. The doors have the same information letter type as the exterior doors.

Sauna door, *Saunaovi*

Sauna door is a commonly used door in Finnish construction. For the architects at JLL Finland, this door type means spending time to set it up for every project separately and then using it only a few times in the project. The interviews revealed that the “sauna door”, seen in figure 10, was the door type most desired in the favourite settings.

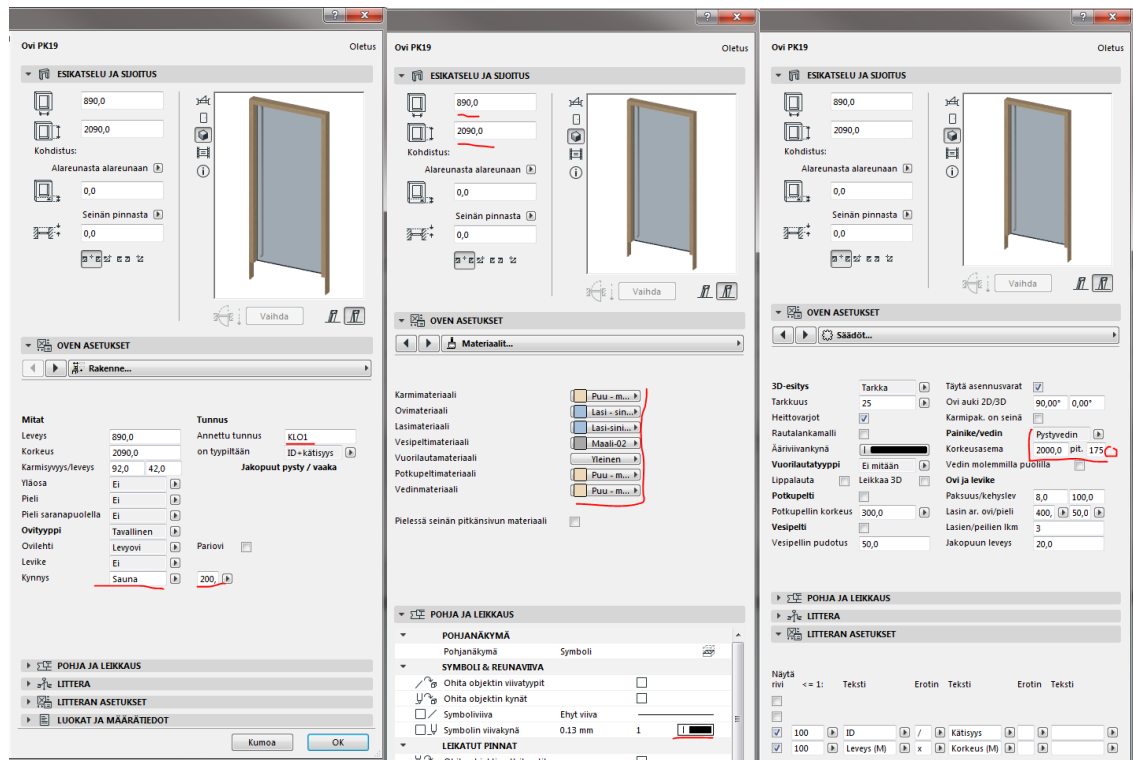


Figure 10. Sauna door.

The same standard sizing is used for the “sauna door” as for most doors. The most important difference is in the threshold style. A “sauna door” uses an open threshold style called “Sauna threshold” with a height of 200mm. The favourite settings materials of this door are wood and glass. The glass panel lets light into the sauna, and wood with its low heat transfer coefficient ensures the door to be safe to touch. The sauna door uses the same information letter and IFC specifications as the other interior doors. The door ID is “KLO1”. The handle of the door was set to be at 2000mm to achieve the desired look in 3D representation. Once again, all pens used in 2D are set to pen 1.

Glass wall door, *Lasiseinäovi*

A glass wall door is a commonly used door type for offices. Glass walls have become popular in offices and the width of glass walls determines the characteristics of doors that can be attached to the glass wall system. The door parameters in the template are made to match Muotolevy door types.

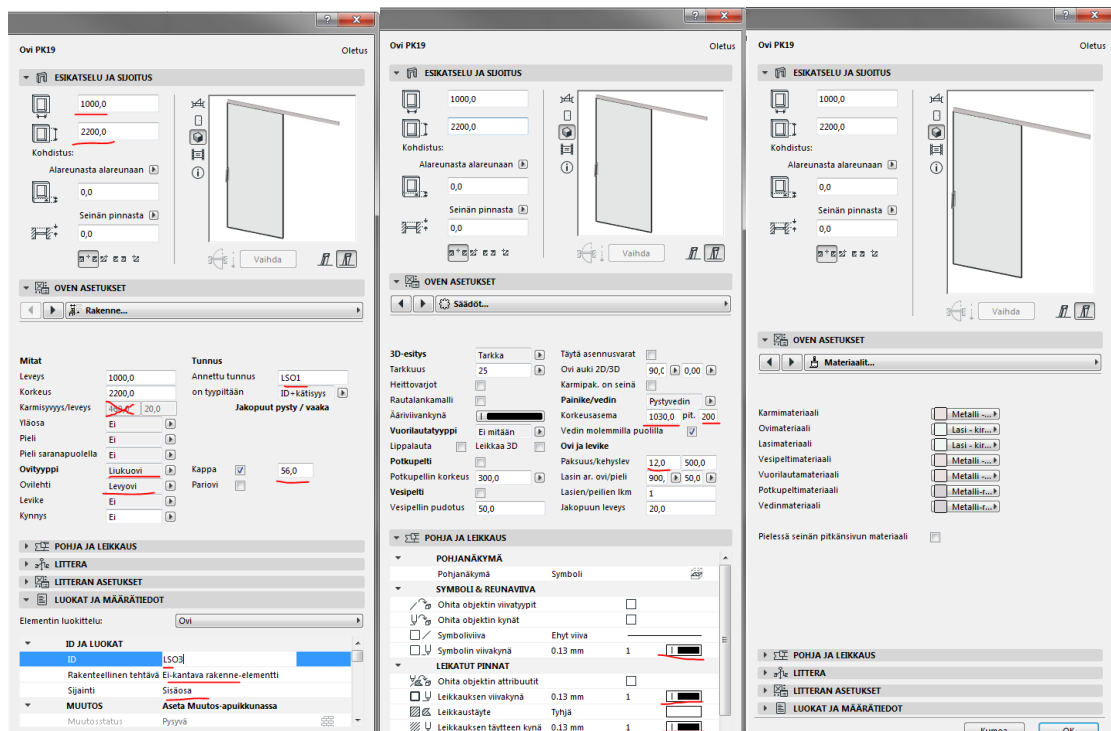


Figure 11. Glass wall door.

Figure 11 shows all the important parameters the glass wall door needs. The height, width and frame thickness follow the Muotolevy door specifications. The door does not have a threshold, but in reality it should have a rail for rollers. The IFC specifications are set to “non-load bearing”, “inside” and the ID is “LSO1”. In figure 11 the ID is LSO3 due to the door being the third of its kind in the model. The height of the handle is 200mm and it is placed at 1030mm from the bottom of the door. The glass pane thickness is 12mm for a door of this height. The glass thickness depends on the size of the door. Once again all pens, which define the 2D drafting line colour, are set to pen 1 to achieve a clean and simple floorplan. The glass wall door is given the same information letter as the other doors.

3.3 Window tool

The default favourite windows in the Finnish version of ArchiCAD are almost never used by architects at JLL Finland. The default favourite windows do not comply with the Finnish construction standards and some types, like the sliding window or the bay window, are a waste of space in the favourite's list. The questionnaire brought forward three types of windows that are commonly used, and suggested how these windows should be displayed in 2D plans. The windows are listed below with the name given also in Finnish.

Window opening, *Ikkuna Aukko*

The most common way to model a window opening hole is to use the window tool and the window opening object. Figure 12 shows some of the parameters that should be listed for the window opening object.

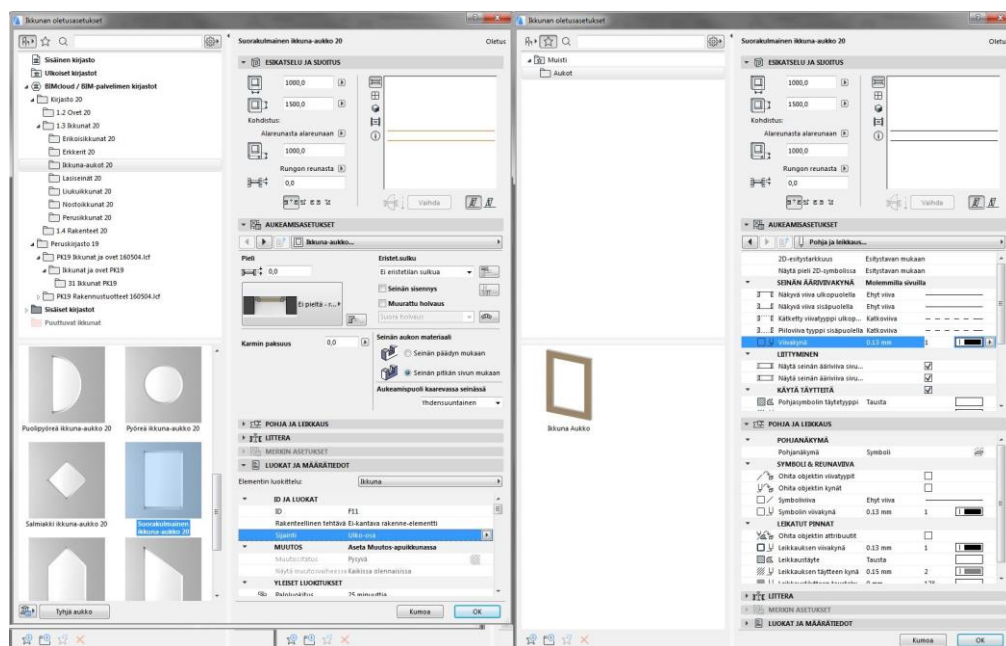


Figure 12. Window opening settings.

For the JLL Finland template, the structural function is set to “non-load-bearing” and the position “outside”. Also the pen colours are modified. For a clean drawing, plain black lines which use pen 1 are defined.

Asymmetric double window, *Kaksiosainen Ikkuna*

An asymmetric window is a commonly used window type in Finland. One side is usually easy to open and used for manual ventilation. The architects need an easy way to indicate on which side the smaller opening is. For the asymmetric double window, reveal depth and thickness can be set which will be displayed in 2D plans. Figure 13 below shows the process of modifying the window.

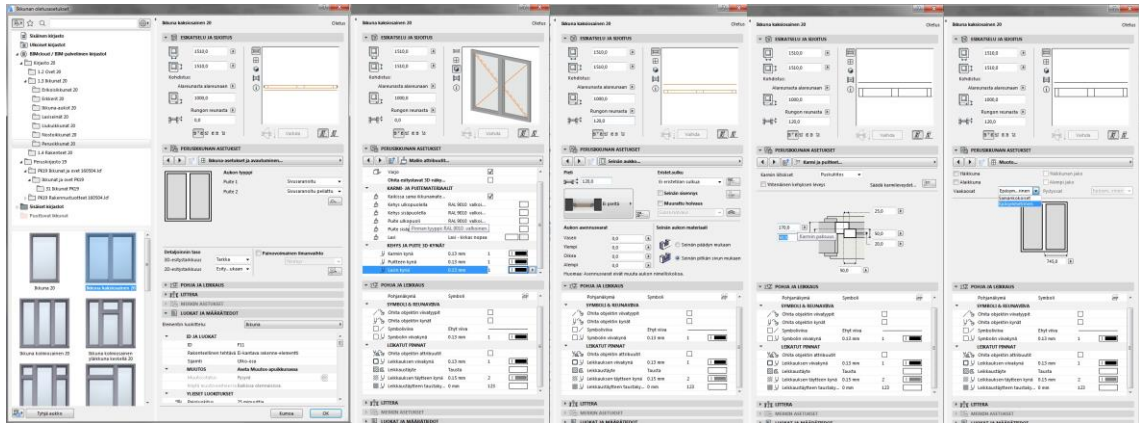


Figure 13. Asymmetric double window.

The asymmetric double window is identified as “non-load-bearing” and positioned on the “outside” in the IFC settings. The 2D display settings tab has all line colours set to pen 1 to achieve a clean look on plans. The questionnaires showed that the architects seemed to prefer the reveal depth to be set at around 120mm. The thickness of the window is set to a standard 170mm. The final parameter to set is the window pane type, which is set to be asymmetric. These parameters are saved in the favourites list. It is important to note that the last parameter settings tab used is the first one to open when the window is used.

Single pane window, *Ikkuna*

A single pane window has a lot in common with the asymmetric double window. The major difference is that the single pane window has a fixed glass and when it is used for modelling, the first parameters tab to open takes the user to glass fixing settings. The fixed glass option makes 2D plans and sections look cleaner.

For the purposes of the JLL Finland template, the “single pane window” is displayed in two figurations. Figure 14 shows the final list of favourite windows.

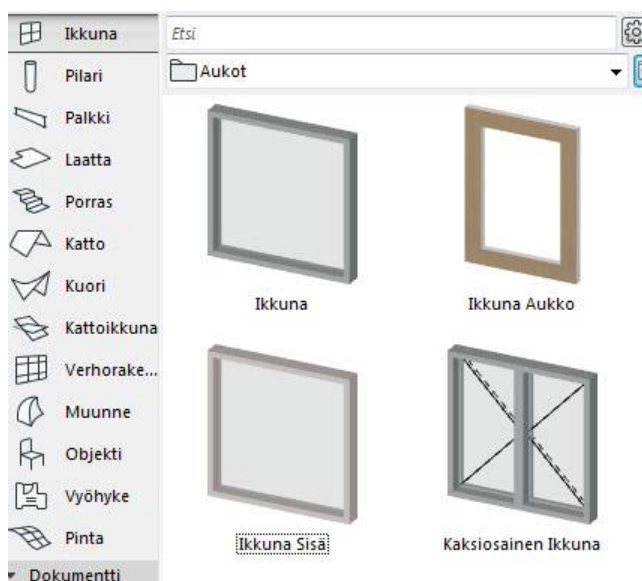


Figure 14. Favourite windows in JLL Finland template.

While all windows are positioned on the “outside”, one “single pane window” has an IFC position setting as “inside” for interior works. This window is named “Ikkuna Sisä”. “Interior windows” are used often in offices, and for further BIM studies and simulations it is vital that the “interior window” is classified as such. Besides the IFC position, the interior single pane window is also thinner than the regular single pane window, at only 92mm thick, because interior walls are usually 92mm to 200mm thick.

3.4 Pillar tool

Pillars are in most cases load bearing elements of a building. ArchiCAD has a good list of pre made pillar types that only need a bit of modification for them to meet the COBIM 2012 requirements. The interviews with architects and engineers revealed no specific desires. For the JLL Finland template, COBIM 2012 modelling requirements are followed when making changes. The main problems with the pillars in ArchiCAD are that, first, the height of the pillars is 200mm less than the height of a story, second, the IFC specifications are not set, and finally, the layer used is wrong. These problems are addressed below.

Interior and exterior pillars

For the JLL template, three pillar types are used in interior spaces and two types are meant for exterior use. The “interior pillars” are a regular square pillar, a round pillar and an H-pillar made out of steel. Exterior pillars are a square pillar and a round pillar. Figure 15 shows the ArchiCAD settings for the pillars in the JLL Finland template.

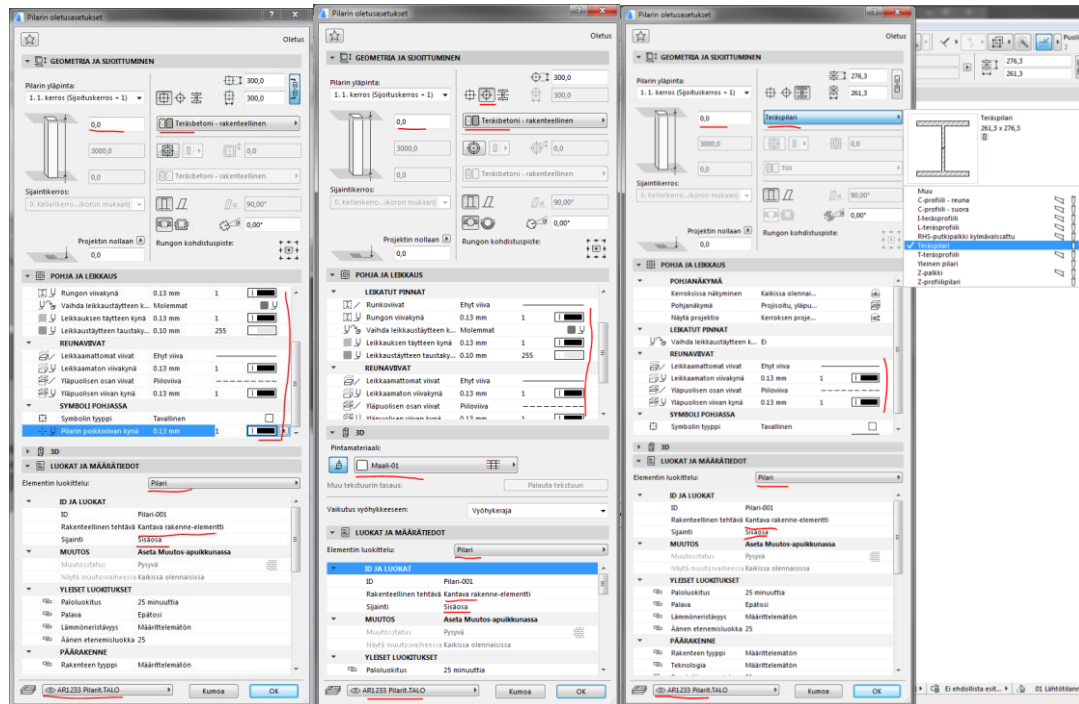


Figure 15. Pillars.

All pillars are 3000mm high, which is the height of one story. The material of the H-pillar is steel, the other pillars are reinforced concrete. The IFC specification is “load bearing” and the ID is “Pilari-001” as in the default. The interior and exterior pillars have a different IFC location setting. The interior pillars are classified as “inside” and the exterior pillars “outside”. For a 2D representation, all pen settings are set to pen 1 and the pillars do not have the centre line displayed. All pillars use the ArchiCAD layer “AR1233 Pilarit”.

3.5 Column tool

The columns in the basic ArchiCAD template have a number of pre-made versions. However, none of them suit the JLL Finland template. All columns lack an IFC specification, the placement height is defined to be the middle of the column and the layer does not match the Talo2000 system. The ArchiCAD columns are removed from the favourites tab and replaced with two new types, an interior column and an exterior column. Both types of columns are assigned a placement height measured from the top of the column. For the material, reinforced concrete was used and the 2D line setting is pen 1. Both columns are assigned a layer named “AR1234 Palkit” and the IFC specification was set as “load bearing” and the location as either “inside” or “outside” according to the column type.

3.6 Slab tool

The slab tool is used to model floors and ceilings. As an exception, the slab tool can also be used to model flat roofs, but it is recommended to use the roof tool instead. For the JLL Finland template, two slab types were created, a floor slab and a false ceiling slab. A roof slab was not included in the slab list because according to good practices of modelling, even a flat roof should be modelled with the roof tool [16].

False ceiling, *Alakatto*

A false ceiling should be modelled with the slab tool in architectural models. Analysis of prior models showed that the slab tool was almost never used, instead the location of the ceiling was marked with the 2D line tool. To steer designers towards using the slab tool more often, a ceiling slab was created. Figure 16 shows the ceiling slab on the left. The ceiling slab is 20mm thick and the height is 2420mm from the floor level to achieve a ceiling height of 2400mm. The material is “gypsum board” and all 2D drafting lines are defined as pen 1 for a clean and clear representation on floor plans. The IFC specification mark the slab type as a “non-load bearing”, “ceiling” with the position “inside” the building. The layer was set to “AR1324 Sisäkattopinnat” to follow the Talo2000 naming system.

Floor slab, 032 Ontelolaatta

The floor thickness varies from building to building. In the JLL Finland template, there is a general floor slab that has the thickness and name according to the most commonly used concrete floor element, the 320mm concrete panel. Settings tab for the floor slab can be seen in figure 16, on the right.

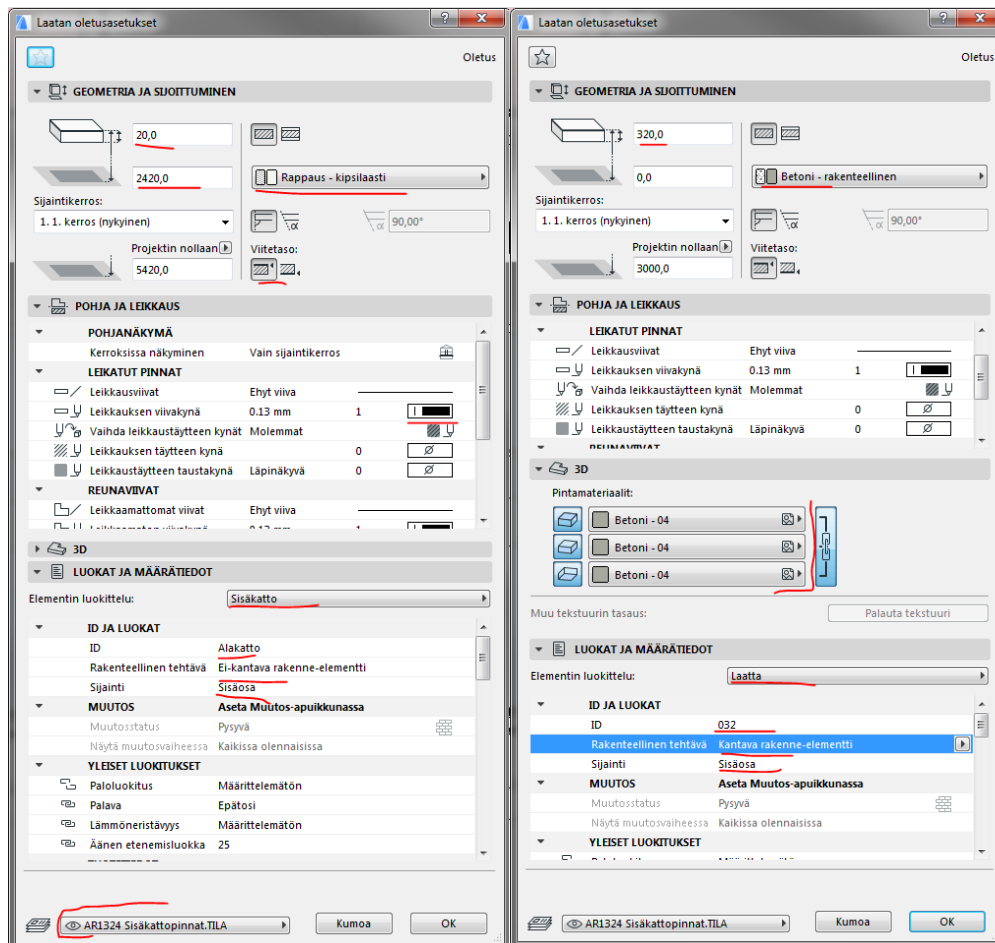


Figure 16. Ceiling slab (left) and floor slab (right).

The slab is 320mm thick and its elevation starts from the top of the slab, as instructed in the modelling guidelines of COBIM 2012. The material of the slab is structural concrete. The IFC specification define the slab as “floor slab”, the element is “load bearing” and located “inside” the building. The layer was set to “AR1235 Väliohjat”.

3.7 Stair tool

Stairs are a complicated part of any structure. Because most stairs need to be engineered specifically for the project at hand, making general stairs is complicated. Nevertheless, some general stairs can be used in the preliminary, planning and design phase. The best approach to creating pre-made stairs for the template is to have a consistent 2D representation for all types of stairs and to make sure that the IFC specification is correct.

General interior stairs, *Yleinen porras*

For the JLL Finland template, three sets of general stairs are created. They are straight stairs, round stairs and a staircase with one central landing making a U-turn. All stairs represent their function on 2D floor plans in a simple and clear way without leaving out important information. Figure 17 shows the details of the settings of the stair types.

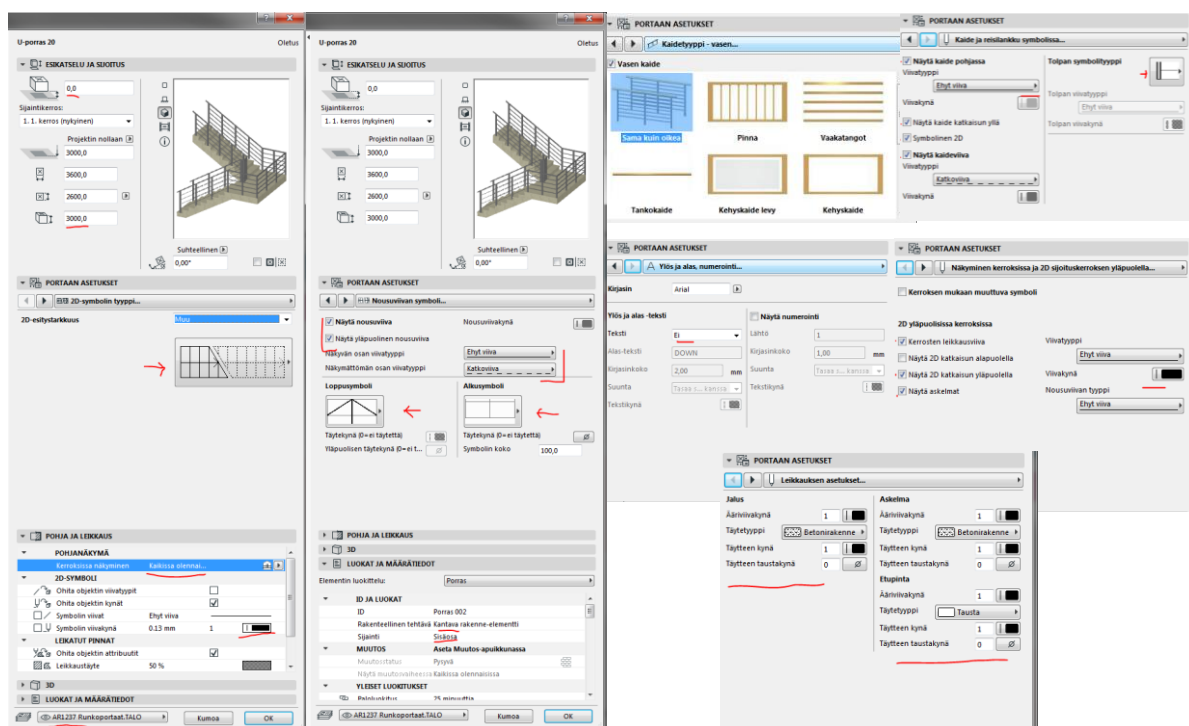


Figure 17. Stair settings.

All interior stairs are one story high, in this case 3000mm. The starting elevation is the 0 point of the current story. The 2D representation style is a simple stair style with the part of the stairs that is above the floor plan cut line is represented with a dashed line. The

stairs are also visible on all floors they are situated on, meaning that the floor above also displays the stairs. In 2D the stairs have a line that shows the upwards direction with a wide arrow. The starting point does not have a specific marking. Steps are not numbered to keep the plan clean and simple. The stairs also have a railing on both sides which is represented on the 2D drawing without any supporting posts. All lines in the 2D plan, and in the section view, use pen 1 for simplicity. IFC specifies the stairs as a “load bearing” element that is situated “inside” the building. The stairs are placed on the layer “AR1237 Runkoportaat”.

External stair, Kierreporras – ulko

“External stair” is the fire escape staircase located outside of a building. These kinds of stairs are widely used in JLL Finland because the company often deals with commercial buildings. The key characteristics of the external stairs are the material used, the width and the need for a structural pillar to support the stairs. The settings can be seen in figure 18.

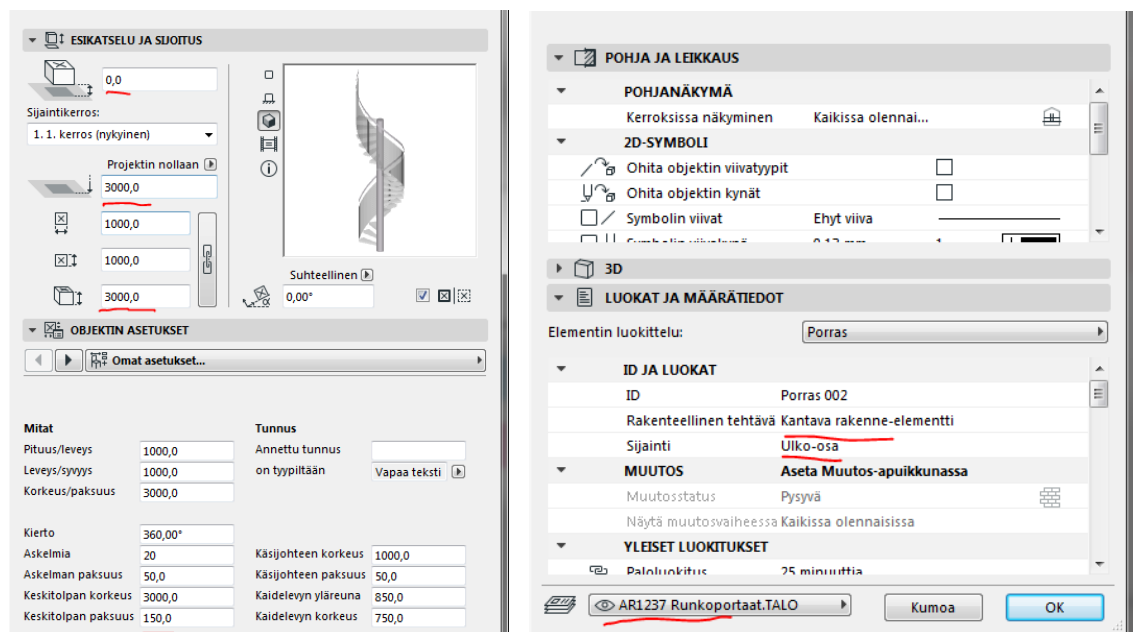


Figure 18. Escape stairs.

The external stairs are located outside of the building and thus the IFC specification is “outside” of the building and the stairs are “load bearing”. The pillar width is 150mm and the materials used are corrugated metal and stainless steel. Because the height of the fire escape stairs depends on the escape route, the stairs are saved to show the field for

editing the stair height and support pillar height as the first when the settings tab is opened. The layer is set to “AR1237 Runkoportaat”.

3.8 Roof window tool

The roof window tool is used to place windows and other objects on the roof. For JLL the important objects in this category are roof hatches and safety related equipment. Due to the nature of the tool, the object layer takes the layer of the roof and not many other specifications can be set. Figure 19 shows the list of favourites added to this tool for JLL Finland.

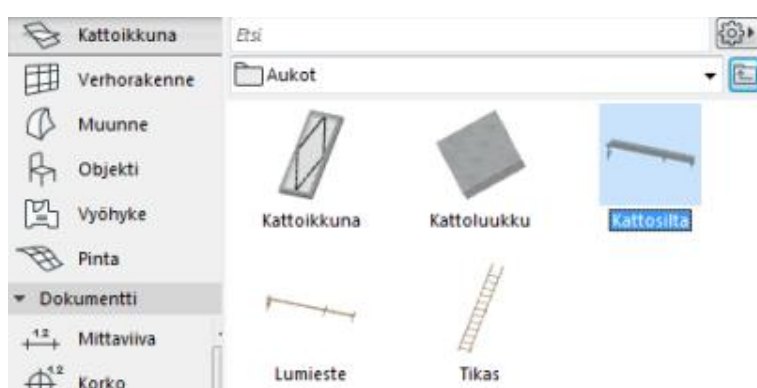


Figure 19. Roof window objects.

For all objects the IFC specification is “outside” of the building. The “Kattosilta”, “Lumieste” and “Tikas” are classified as the element type “railing” because they are safety equipment used on roofs. Structurally the objects are “load bearing” because they need to withstand the weight of a person. Both the roof window and roof hatch are “non-load bearing”. For 2D representation, all object line settings are assigned pen 1, in other words, the lines are black.

3.9 Curtain wall tool

Curtain walls are non-load bearing façade elements. The curtain wall modelling tool is one of the more complicated tools ArchiCAD has to offer, and no curtain wall is alike. In the JLL Finland template, the curtain wall has IFC specifications “non-load bearing” and “outside” the building. The tool is assigned the pen 1 for all line colours and the layer is “AR1241 Ulkoseinät”.

3.10 Tool for common objects

The “object tool” can be used for a variety of modelling applications. In most cases it is used to add objects like furniture into the model, but it can also be used to replace some of the other modelling tools. The objects library has for example concrete slab elements, roof beams, EU-standard metal beams and many more. In the JLL Finland template the architects wanted to have a selection of most commonly used bathroom appliances and kitchen furniture. Interior designers had an overwhelming list of possible solutions for this tool. Since the goal of the template is to make the user interface easier, the objects tool is not changed much. The objects tool has only the most commonly used bathroom appliances in the favourites list. The appliances were assigned a correct layer, “AR21 Putkiosat”, and the 2D representation style was set to as simple as possible with pen colour 1.

3.11 Zone tool

In ArchiCAD, zones are 3D elements with a floor plan representation consisting of fills and a zone stamp. The zone tool is used to mark areas of a project and to show some information, like the net area and use type. The zone tool is extensively modified due to the nature of the tool in BIM software. Besides the use mentioned before, the zone tool is also used for energy calculations and room listing, and it is a vital tool in quantity take-offs.

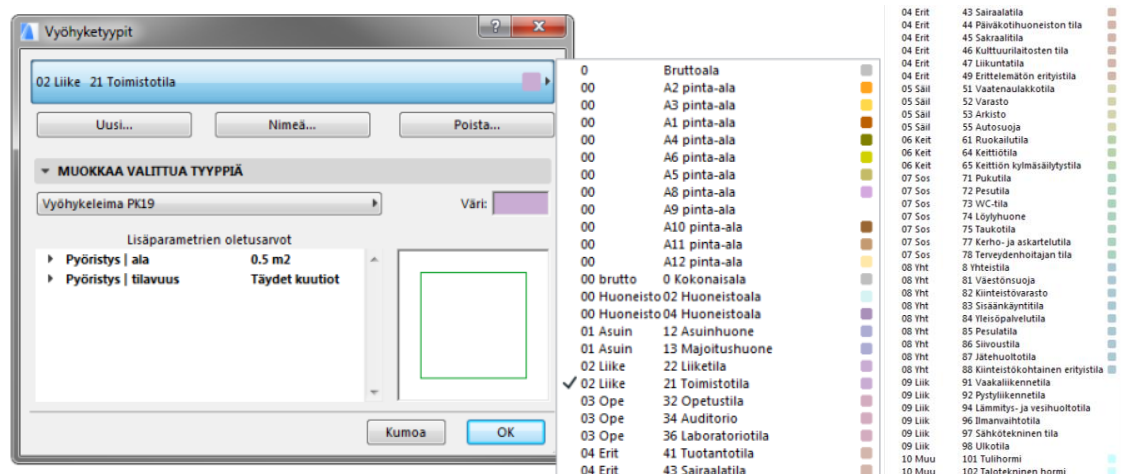


Figure 20. Different zones made for the ArchiCAD template.

To get architects and interior designers more inclined to using the zone tool, instead of regular fills, many different zone types have to be created. The zone types are named according to how the building area is used, and the usage area types are further specified. The aim is to make the zone tool easier to use than using the fill for marking different areas. The full list of different zones can be seen in figure 20. All zones are assigned a zone stamp type PK19 because most architects are familiar with using that stamp.

Once the different zones are created it is time to modify the favourite zones window. The zones are given the correct layer, “AR9 TILAT JA ALUEET”, the correct height, corresponding the height of a story. To tell the different zones apart in the favourite’s window, the zones are assigned surface materials. The zones are only displayed in 3D if the 3D view override has the zones activated. In most cases the zones do not need to be shown, but in preliminary design, zones are the correct tool for mass design. Figure 21 shows the five favourite zones created and the settings applied.

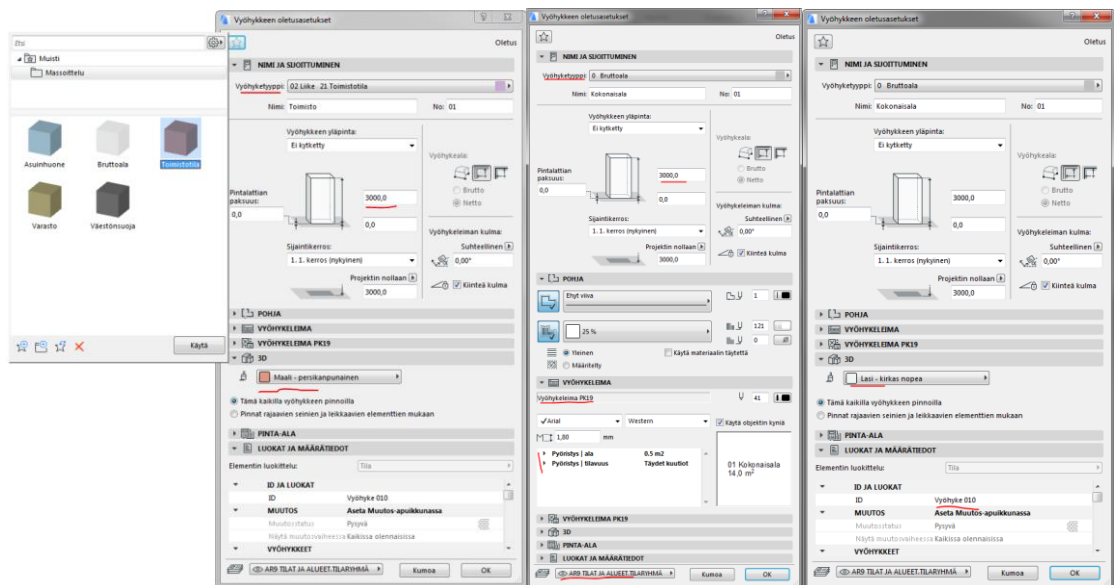


Figure 21. Favourite zones.

The favourite zones are the most commonly used zone types. In 2D representation, the fill of a zone is according to the zone area type. In most cases, when working on a model, an override turns the fills off.

3.12 Mesh tool

The mesh tool is used to create a site landscape and in some cases it can also be used for miscellaneous terrain objects. The basic mesh in ArchiCAD has ridge lines displayed in 2D plans which makes 2D drawings complicated and messy. For the JLL Finland template, three different meshes were created.

Terrain mesh, *Ympäristö Luonnos*

The terrain mesh is the most commonly used mesh. The important parameters that are changed are the 2D floor plan display settings. The mesh uses pen number 1 for all lines in 2D and all ridges are set to be soft. This setting removes ridge lines from 2D drawings. Next the user defined ridge setting has been turned on. This will let ArchiCAD override the smooth ridge setting for only the ridges that designers have specifically defined. With these two settings applied, the final 2D plan displays the mesh like a regular site plan, with height lines according to user specifications. The IFC specifications for mesh are the element type and location, set to “landscape geometry” and “outside” respectively. The mesh layer is set to “AR04 Ympäristö”.

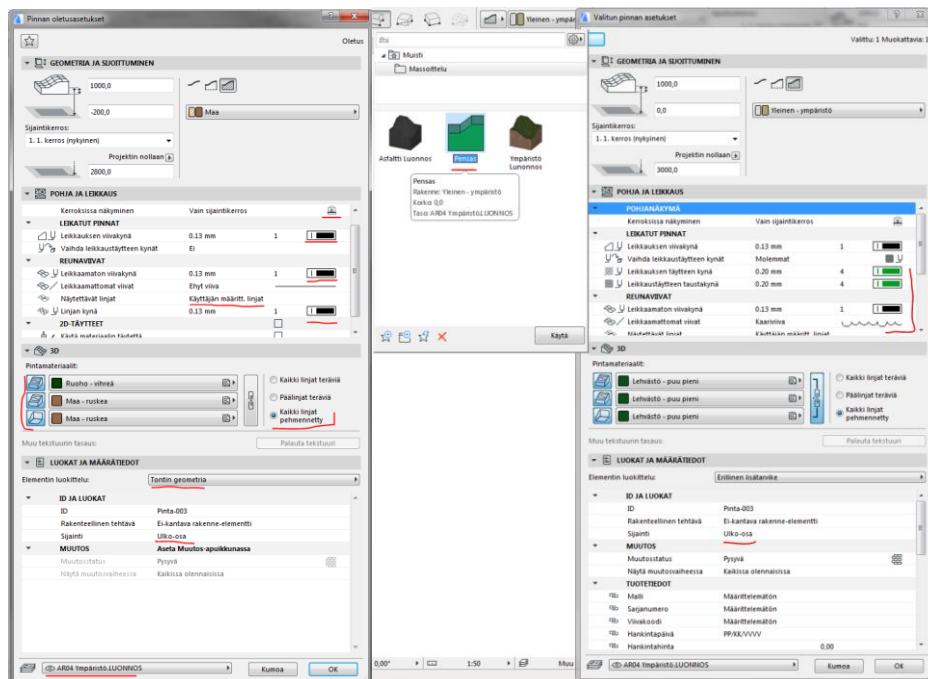


Figure 22. Mesh tool settings.

Figure 22 shows the three favourite mesh elements. For landscape design, roads need to be modelled and that is also done with the mesh tool. A landscape mesh with surfaces set to be asphalt is used for roads.

Garden bush, *Pensas*

One of the objects in figure 22 is a green mesh. This is a special mesh that the JLL architects asked for. This mesh is used to model the garden greenery for sites. The 2D representation for the mesh line type to curvy and the pen is number 4, which represents the colour green in most pen sets. The cut fill, which gives the mesh a fill colour in sections and elevations, has an override making the cut mesh look green. The layer stays the same as the landscape mesh.

3.13 Changes in 2D drafting tools and general settings

The changes described in chapters 3.1 – 3.12 all changes affect the parametric modelling tools. A variety of 2D drafting tools need to be modified to have a well-rounded starting template. They are the dimension tool, line tool and the section settings. Furthermore, the ArchiCAD pen sets are modified and a footer for layouts is added.

Dimension tool

The dimension tool is used to mark the dimensions of objects. The ArchiCAD dimension tool uses a separate layer that does not correspond with the Talo2000 system. The layer is changed and three different dimension types are added to the favourite's window. The dimension types differ from one another by the text size. For a clean floor plan, the overall measurement is displayed with the biggest font size and as measurements go into more detail, the font will be smaller to better fit into the drawing. This approach makes it clearer for the reader to understand which measurement goes with which dimension. All dimensions use the layer "AR-D2 Täydentävät mitat".

Line tool

The desired modelling approach would have the model with no lines used at all. The only exception is the fire department line. The fire department line has to stand out from the rest of the drawing. That is why the line is assigned pen number 20 which is a red pen

in all of the pen sets. The layer of the line is “AR941_OS-PALO” and the line type is a “dash dot line”. In addition to the fire department line, a line for marking ceilings was added. The ceiling line is used to mark the height and location of a false ceiling. The modelling could be done with a ceiling object that has the ceiling height line attached to it, but it would be more complicated and does not follow the COBIM 2012 modelling requirements. The line is of the same line type as the fire department line. The only difference is in the pen colour and the layer used. The pen colour is black, and the layer is “AR1323 Sisäkattorakenteet”.

Section tool

The section tool has a wide variety of settings to achieve the kind of section desired for the occasion. For the JLL Finland template, two different section types are created. Figure 23 shows how these sections differ from each other. The first section is a simple cut of the building which aims at showing the structures of the walls at the cut location. The second section aims to show the room and has a depth of view. Both are commonly used section styles.

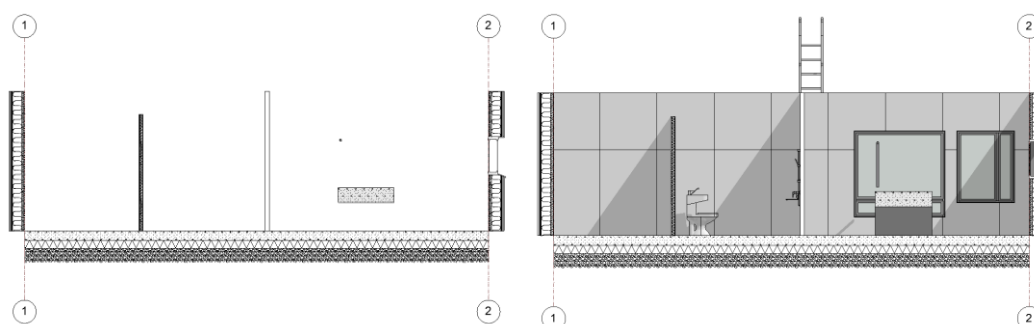


Figure 23. Sections of a building.

The sections use layer “AR-J1 Leikkausmerkinnät”. For the first section, the depth of view is removed. The second section has surfaces according to the materials used. Both sections display the full length of the elevation. On floorplans the sections are represented with a hidden line with arrows at ends pointing at the direction the cut looks at. The sections are named “Leikkaus” for the simple cut and “Leikkaus Varjostettu” for the coloured version.

Pen sets

Different pen sets are used to display the floor plans, sections and elevations according to need. The ArchiCAD pen sets tend to have a very thick line weight which causes problems when printing or saving drawings in PDF. For the JLL Finland template, four new pen sets are created and the ArchiCAD pen sets are modified to have thinner pens. In figure 24, the pen colours circled with a red marker are the JLL Finland specific colours.

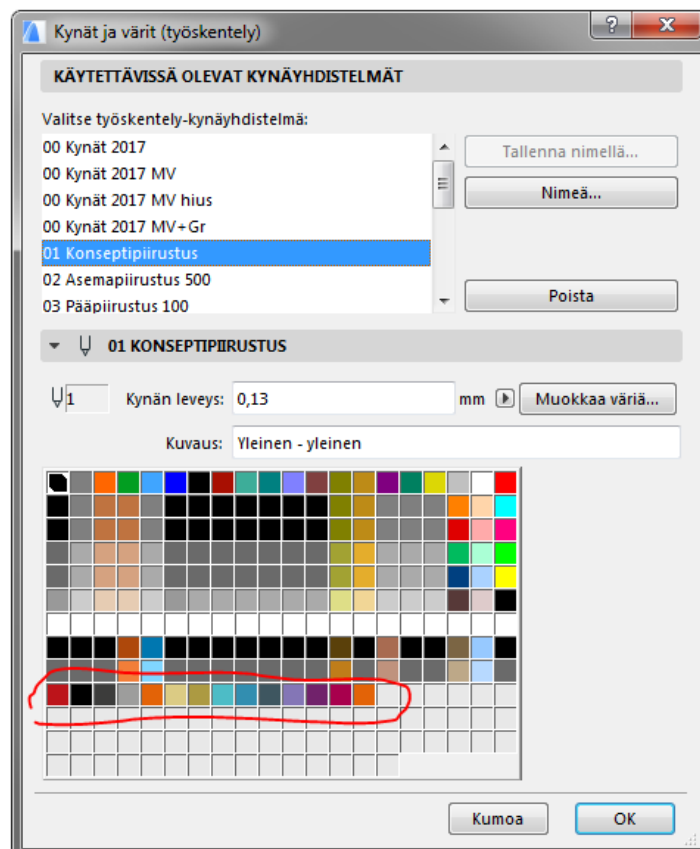


Figure 24. Pen sets.

The colours of the pen set are chosen according to the JLL Finland colour scheme. These colours are added to all pen sets, as is the colour red on the upper right-hand corner of the colour list. The first four pen sets, seen in figure 24, are mostly black and white pens, with the exception of the JLL Finland specific colours. The “MV hius” pen set, seen in figure 24, has all pen thicknesses set to 0 to be used on large scale drawings. “MV + Gr” in figure 24 has black pens and a variety of grey pens.

Layouts and footer

A footer is an element of layouts that contains information about the project. Most companies in Finland follow a general footer layout with only minor changes to it. The footer has to make it clear to the reader what the plan represents and the dates of important milestones like initial release date and dates of changes. In addition to the footer, layouts with various sizes are created. The sizes vary from A4 paper to 8x3 A4 sheets.

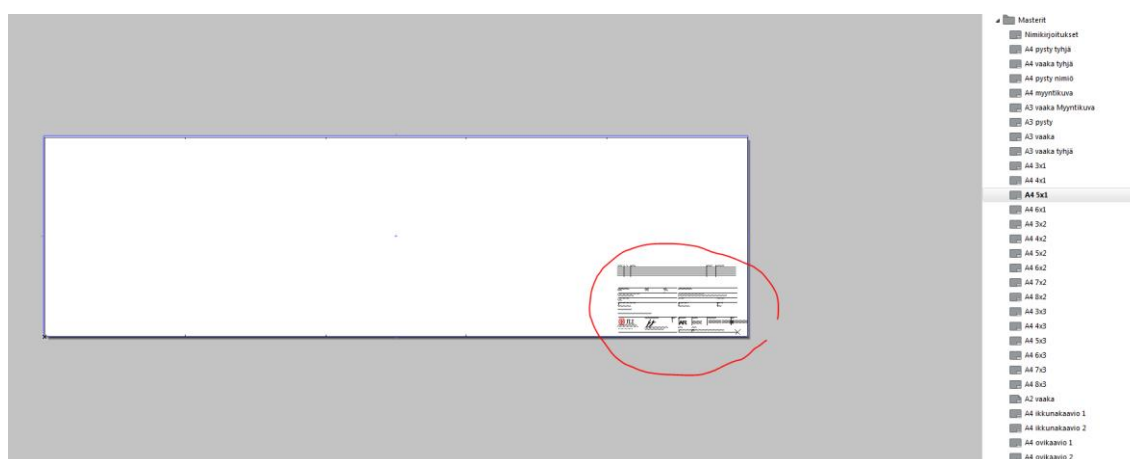


Figure 25. Layout and footer.

Figure 25 shows a 5x1 A4 layout with a footer. These paper sizes are the most commonly used for layouts in JLL Finland. The footer is the same for most of the layout sizes. A smaller simpler footer is used for A4 and simple A3 layouts because of paper size restrictions.

4 Result and feedback

The final result of the final year project was a new starting template in ArchiCAD for JLL Finland, fulfilling the main goal of the thesis. In technical terms the result is an ArchiCAD template file “ArchiCAD aloituspohja JLL 2017.tpl” which is currently used and tested by the designers at JLL Finland. The new template has a clearly different visual appearance from the native ArchiCAD starting environment. Figure 26 compares the working environment when starting a new project in ArchiCAD.

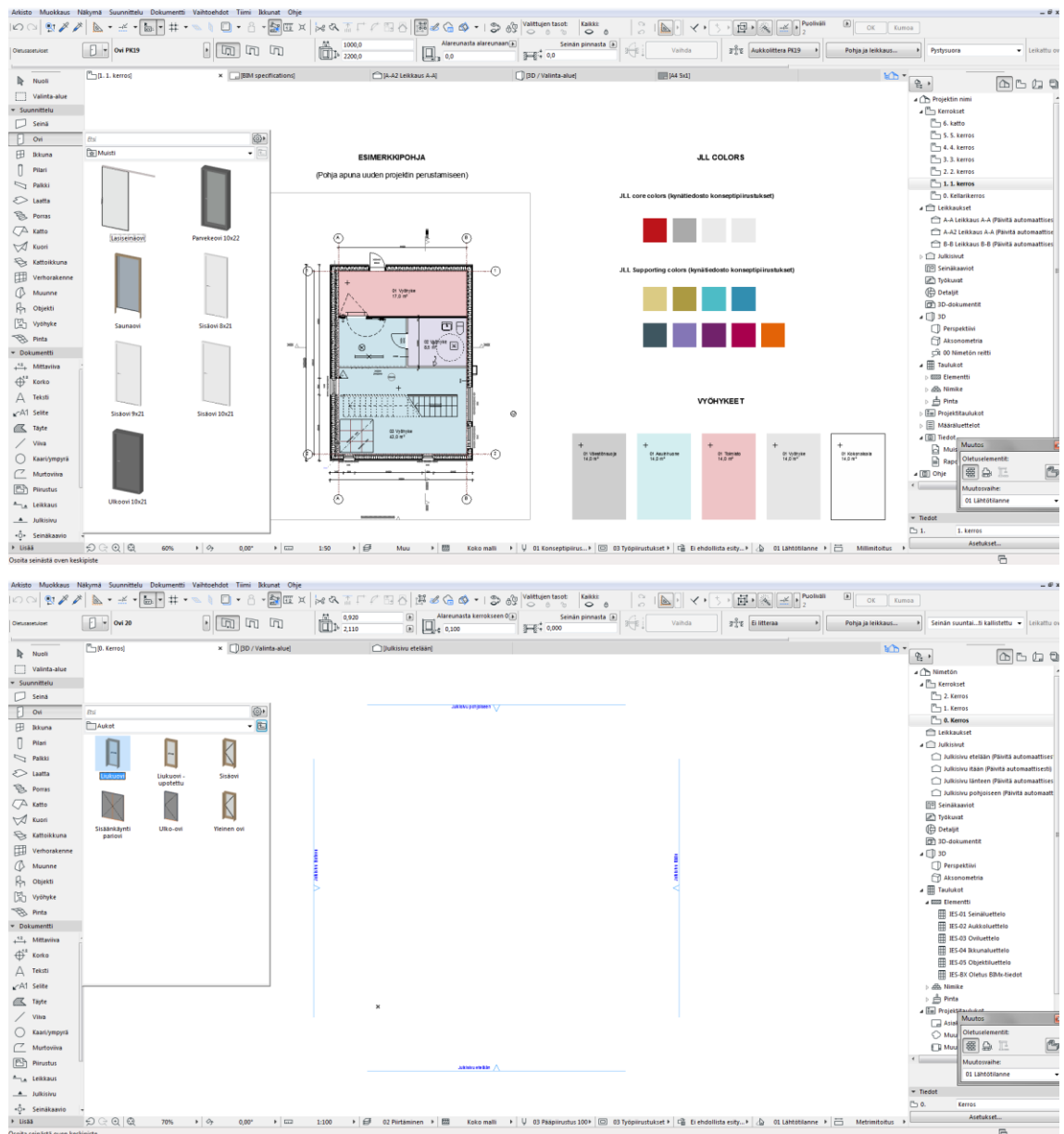


Figure 26. Starting view comparison. New template on the top and the original in the bottom.

A sample building and a colour map is added to the starting environment. The sample building can be used to copy walls, windows and other elements without using any modelling tools. The sample building and colour map can also be used to see how the tools react to different model view overrides. In the lower part of figure 26, there is the original ArchiCAD starting environment with the favourite windows tab opened. The original environment is empty of any guiding figures, and the favourites tab has the original windows listed.

Testing and feedback

The new template is currently used and has been in testing phase for some weeks. Four designers have started a new project during this time and the feedback from them is based on regular use at the office. The feedback has been positive, with many recommendations for further changes. After the initial testing, the designers decided that the favourites list for tools need to be change to use “Peruskirjasto” window objects. The native library windows lack two important parameters; the window casing type, according to Finnish standards, and the number of glass panes used. The native windows also display the information letter in a different way. In addition to the window tool, the designers asked for the favourite tools to be numbered. This is because the favourites tab has all the pre-set tools listed in an alphabetical order. It would be better if the favourite tools were listed in a logical fashion, for example doors should be listed from exterior door to the smallest interior door. Small mistakes in using Talo2000 layer system were also found and have been fixed during the testing phase.

The new models created by designers that use the new JLL Finland template, have also been analysed to see if the models follow the best practices set by COBIM 2012 regulations. The models can now be displayed in structural form with load bearing elements separate from non-load bearing elements. Window and door list generation is more effective, but further work is still needed. The testing has revealed an error in the system that has been notified to Graphisoft for updating. The IFC ID field does not work as it should. Different types of same tool do not keep the ID assigned to them. The ID field changes for the tool according to last ID given. This error makes automatic list generation inefficient and causes problems when exporting ArchiCAD to any IFC based construction software.

Most of the recommendations and requests for further updates in the template concern model view overrides. The recommendations and requests given will be dealt with in the future and the following will be added to the template:

- Pen sets with modelling elements with a specific pen number
- Updated renovation overrides
- Surface library overhaul with less surfaces
- ArchiCAD to DWG translator settings
- Project publishing sets, PDF and DWG

- Layer list settings, to display the list easier
- Elevation tool pre-sets with two different visual styles
- Object library update

Designers at JLL conclude that the template does speed the work. From the technical point of view, the new models contain more information. This means that all of the set goals have been met.

5 Discussion

The main benefits of the new JLL template are in the way it enhances workflow and helps the architectural office to produce consistent drawings. Every office should have its own style and the new template helps to make all drawings have a common theme. The new template will help designers to produce marketable material that stands up to the high standards set by JLL Finland.

Time saved in the modelling process, is a resource that can be used elsewhere. Every project has a set number of hours designers can work with. With an enhanced modelling process, designers can spend more time to figure out better design options or the saving in time can be used to increase the profit margin on a given project.

The test use of the new template looks promising. Already during the testing phase the template has made the modelling process faster by removing the time needed to set up building elements. So far the new template has not shown its full benefits because the full impact will be revealed when new projects reach their end phase, and the models are sent to outside parties like structural engineers and contractors.

The main reliability issue using this template is connected to the user. Even though the modelling tools have been modified, it is still vital that the designers use the right tool for the right job. The designer can still create new building elements that do not have any vital parameters listed, or use incorrect tools for modelling. To reduce the risk of improper modelling practices, a number of steps should be taken: 1) A user guide can, and should, be created. 2) Training sessions should be held for all designers using ArchiCAD. 3) The quality of modelling can be checked by analysing the models during all design phases.

These three steps should mitigate the risk of improper modelling and the last step, the quality testing, is something that should be done for every project.

Future outlooks

Since BIM software is constantly updated, and all major software makers are moving towards a common language, the outlook in this field of computer aided building modelling is good. This means that ArchiCAD users will benefit from a well prepared starting template in the future. There are no restrictions to how thorough a starting template can be. During the process of making this template, designers got intrigued by the idea of having a well-planned template that enhances their work flow. After office specific tweaks and modifications are made to this template, the next step is to start including material information to improve the simulation capabilities in the program. Proper models also improve the teamwork between architectural offices and engineering offices. If JLL Finland starts constantly producing models that engineers have no software issues with, new partnerships will be created, benefitting both sides. An ArchiCAD template is only a small part of the program, but it has a major effect on how the program is used. As ArchiCAD gets updated and new versions are released, so should the template be constantly updated and new aspects added to it.

6 Conclusion

The goal of this thesis was to create a template for ArchiCAD that would help to enhance productivity and make the final models contain more information for IFC files. After the testing phase it is now clear that, even with the few minor changes needed, the new models contain more IFC data and the workflow is faster. The IFC data is increased because the pre-set tools have the necessary IFC specifications included. The workflow was enhanced because the need to remodel commonly used building elements was removed with the use of the favourites tab. All of the above was made in a way that follows the rules and regulations set by the COBIM 2012.

The reliability of proper modelling depends on the designers using the tools in an appropriate manner. If the template is used in the proper manner, future projects can be finished faster and in a more efficient manner. Teamwork with structural and HVAC engineers can be made more fluid because a properly modelled project can be exported in the IFC format. To decrease the risk of inappropriate modelling, a user manual or in-house training sessions should be made.

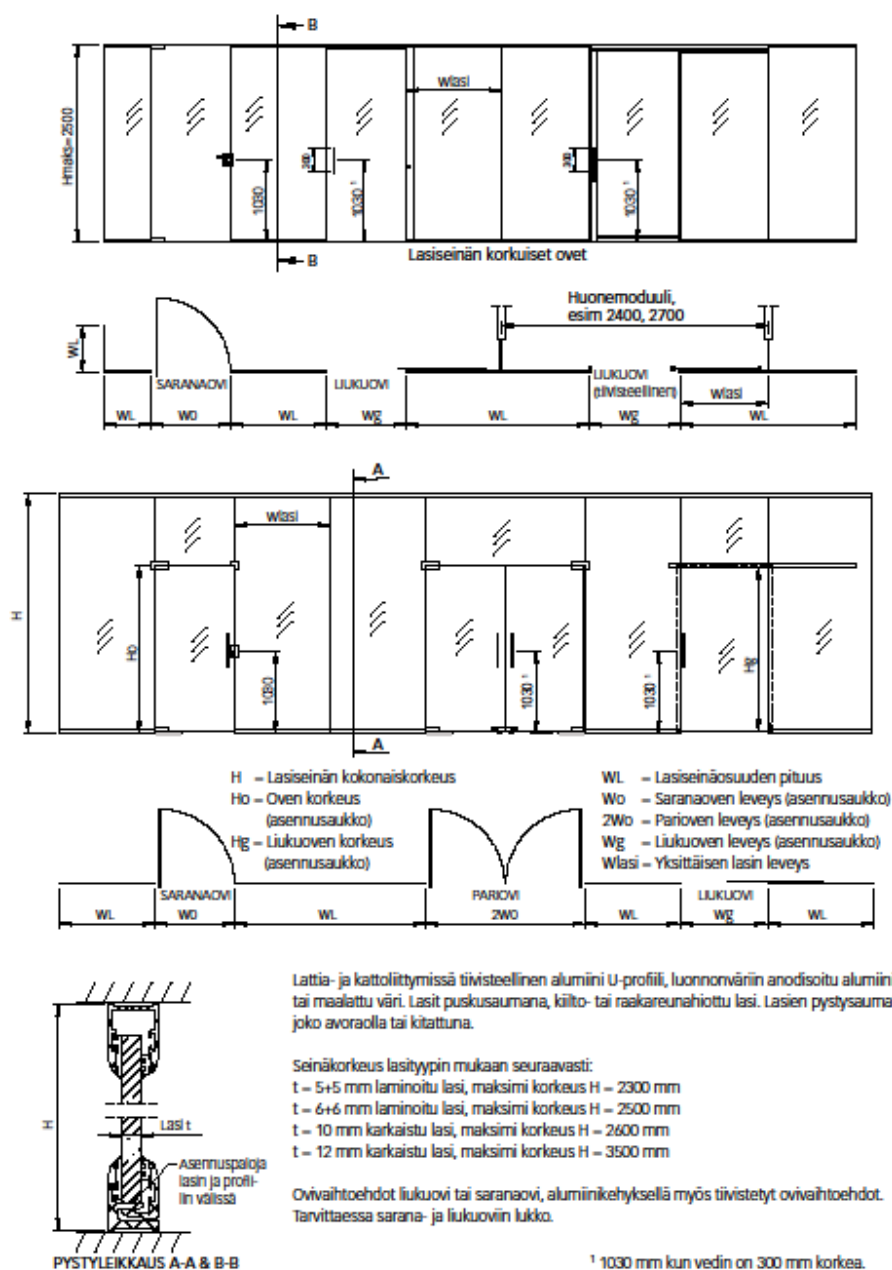
From the feedback given, it seems that the new template has given designers better understanding of BIM in general. Already there is talk about further modifying the template and about how this process can be used to take the company forward in the ever changing BIM field. With proper modelling practices, the new template will let designers use preliminary energy simulations, speed up tedious lists making, like door and window lists, and make the company stand out from most other architectural offices in Finland.

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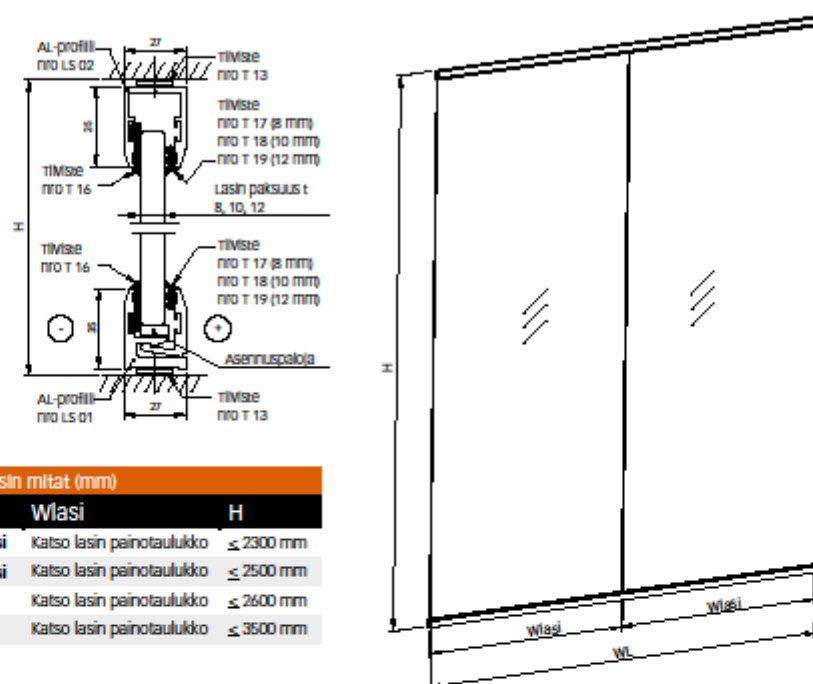
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Muotolevy glass walls and doors

MUOTOLEVY **TILARATKAISUT**



ML-LASISEINÄJÄRJESTELMÄ



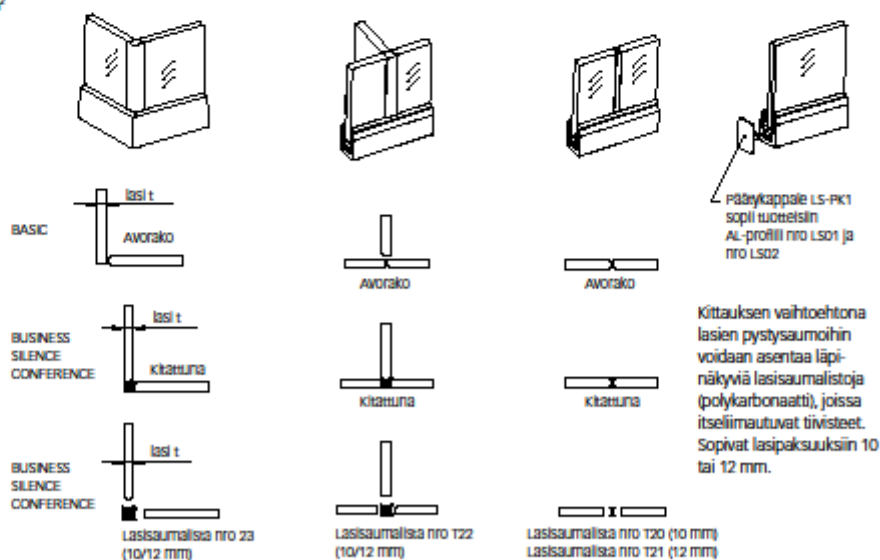
TAULUKKO LS 03 - lasin mitat (mm)

	Wlasi	H
5+5 mm laminoitu lasi	Katso lasin painotaulukko	≤ 2300 mm
6+6 mm laminoitu lasi	Katso lasin painotaulukko	≤ 2500 mm
10 mm karkaistu lasi	Katso lasin painotaulukko	≤ 2600 mm
12 mm lasi	Katso lasin painotaulukko	≤ 3500 mm

Painot:

Lasi 10 mm: 25 kg/m²

Lasi 12 mm: 30 kg/m²



MUOTOLEVY

TILARATKAISUT

TAULUKKO LS 04

LASIN PAINO (kg) leveyden ja korkeuden funktiona 5+5 mm ja 10 mm lasilla 25 kg/m²

KORKEUS	3500	3400	3300	3200	3100	3000	2900	2800	2700	2600	2500	2400	2300	2200	2100
	26.3	25.5	24.8	24.0	23.3	22.5	21.8	21.0	20.3	19.5	18.8	18.0	17.3	16.5	15.8
	35.0	34.0	33.0	32.0	31.0	30.0	29.0	28.0	27.0	26.0	250	24.0	23.0	22.0	21.0
	43.8	42.5	41.3	40.0	38.8	37.5	36.3	35.0	33.8	32.5	31.3	30.0	28.8	27.5	26.3
	52.5	51.0	49.5	48.0	46.5	45.0	43.5	42.0	40.5	39.0	37.5	36.0	34.5	33.0	31.5
	61.3	59.5	57.8	56.0	54.3	52.5	50.8	49.0	47.3	45.5	43.8	42.0	40.3	38.5	36.8
	70.0	68.0	66.0	64.0	62.0	60.0	58.0	56.0	54.0	52.0	50.0	48.0	46.0	44.0	42.0
	78.8	76.5	74.3	72.0	69.8	67.5	65.3	63.0	60.8	58.5	56.3	54.0	51.8	49.5	47.3
	87.5	85.0	82.5	80.0	77.5	75.0	72.5	70.0	67.5	65.0	62.5	60.0	57.5	55.0	52.5
	96.3	93.5	90.8	88.0	85.3	82.5	79.8	77.0	74.3	71.5	68.8	66.0	63.3	60.5	57.8
	105.0	102.0	99.0	96.0	93.0	90.0	87.0	84.0	81.0	78.0	75.0	72.0	69.0	66.0	63.0
	113.8	110.5	107.3	104.0	100.8	97.5	94.3	91.0	87.8	84.5	81.3	78.0	74.8	71.5	68.3
	122.5	119.0	115.5	112.0	108.5	105.0	101.5	98.0	94.5	91.0	87.5	84.0	80.5	77.0	73.5
LEVEYS	300	400	500	600	700	800	900	1000	1100	1200	1300	1400			

TAULUKKO LS 05

LASIN PAINO (kg) leveyden ja korkeuden funktiona 6+6 mm ja 12 mm lasilla 30 kg/m²

KORKEUS	3500	3400	3300	3200	3100	3000	2900	2800	2700	2600	2500	2400	2300	2200	2100
	31.5	30.6	29.7	28.8	27.9	27.0	26.1	25.2	24.3	23.4	22.5	21.6	20.7	19.8	18.9
	42.0	40.8	39.6	38.4	37.2	36.0	34.8	33.6	32.4	31.2	30.0	28.8	27.6	26.4	25.2
	52.5	51.0	49.5	48.0	46.5	45.0	43.5	42.0	40.5	39.0	37.5	36.0	34.5	33.0	31.5
	63.0	61.2	59.4	57.6	55.8	54.0	52.2	50.4	48.6	46.8	45.0	43.2	41.4	39.6	37.8
	73.5	71.4	69.3	67.2	65.1	63.0	60.9	58.8	56.7	54.6	52.5	50.4	48.3	46.2	44.1
	84.0	81.6	79.2	76.8	74.4	72.0	69.6	67.2	64.8	62.4	60.0	57.6	55.2	52.8	50.4
	94.5	91.8	89.1	86.4	83.7	81.0	78.3	75.6	72.9	70.2	67.5	64.8	62.1	59.4	56.7
	105.5	102.0	99.0	96.0	93.0	90.0	87.0	84.0	81.0	78.0	75.0	72.0	69.0	66.0	63.0
	115.5	112.2	108.9	105.6	102.3	99.0	95.7	92.4	89.1	85.8	82.5	79.2	75.9	72.6	69.3
	122.4	118.8	115.2	111.6	108.0	104.4	100.8	97.2	93.6	90.0	86.4	82.8	79.2	75.6	71.9
	136.5	132.6	128.7	124.8	120.9	117.0	113.1	109.2	105.3	101.4	97.5	93.6	89.7	85.8	81.9
	147.0	142.8	138.6	134.4	130.2	126.0	121.8	117.6	113.4	109.2	105.0	100.8	96.6	92.4	88.2
LEVEYS	300	400	500	600	700	800	900	1000	1100	1200	1300	1400			

Vaaleanvihreällä merkitty alue on lasin suosituspaino (maks. 50 kg) asennettavuuden, siirtojen ja työturvallisuuden kannalta.

Vaaleanoranssilla merkitty alue: Lasin paino >50 ≤ 75 kg, joka voi olla asennettavuuden, siirtojen ja työturvallisuuden kannalta epäsuotuista.

Valkoisella merkitty alue: Lasin paino yli 75 kg, joka voi vaatia työmaalla siirto- ja nostokalustoa.